veep

Grounds for Erosion

studies
series

This is a tentative version of the unit for trial purposes. It is not for general distribution. After successful trial, it will be distributed on a non-profit basis.

GROUNDS FOR EROSION

A NOTE TO THE TEACHER:

This is an activity unit on water erosion which can be carried out on the school grounds. To learn about water erosion, the students are encouraged to create their own erosion sytems on the school grounds or in the neighbourhood. Don't panic! It is not proposed to create massive flood damage to public or private property. You can suggest that students duplicate on a small scale those large-scale features dealt with in textbooks. Students are required to repair any damage caused.

To do the unit, a garden hose and numerous pails are needed except if it is raining. Grounds with some slope are helpful but not necessary. If your school grounds are level use the sides of ditches or other artificially made slopes.

It is recommended that the students be divided into groups of two or three and that these different groups study various aspects of the water erosion cycle. For example, while the experiment on rain splash is progressing, another group could be studying characteristics of water flowing across the surface of the ground and a third group could be investigating what this running water does after becoming channelled. If the miniature stream is long enough, a fourth group could be investigating depositional features near the mouth. Encourage the students to share their observations. In this way students can acquire knowledge without having to do every investigation.

INTRODUCING THE UNIT

Prior to the introduction of the unit, you can display pictures related to stream and river features. Perhaps the students could bring pictures from magazines showing river systems as seen from spacecraft or airplanes.*

When you are ready to begin the unit, you may wish to present slides or a film strip showing various erosional and depositional features found in rivers. You can relate water erosion to the water cycle as a whole. See if your students can explain how the features that you point out were formed and whether or not they are changing. Encourage them to suggest how these features might be duplicated on a small scale. This way, they can develop their own experimental methods of investigation.

In your discussion try to establish the importance of identifying a problem, developing a method of attacking it, and basing conclusions upon observations. Since science demands a systematic approach, encourage the students to report their findings in a systematic manner.

Here are some questions which you may ask during the introduction of the unit:

1. How can water erosion be constructive?
2. How can water erosion be destructive?

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* "Eleven Days Aboard Apollo 7" Life, Vol. 65, Dec. 1968, pp. 60-66.
"The Earth from Orbit" National Geographic, Vol. 130, No. 5, Nov. 1966, pp. 645-671.

3. How can the construction and destruction occur at the same general place and time?
4. Have raindrops ever hit you so hard that they hurt? What happens when raindrops hit the soil? How can you find out?

Where Does it All Begin?

The initial activity concerns the effects of rainsplash. Students are often unaware of the erosive effects of raindrops and this aspect of the water cycle is ignored in many texts. Rainsplash is an important agent in the breakdown and movement of soil. Ellison, a soil scientist, estimated that up to 100 tons of soil per acre can be moved in one rainstorm.

For Your Information
Ellison's article is an excellent one for students to read after they have done their activities. It is interesting and the photographs are particularly relevant. This article is representative of a scholarly piece of writing in a semi-scientific journal. The title is "Erosion by Raindrop". Scientific American, November 1948, Vol. 179, No. 5, pp. 40 - 45 or Offprint 817. The offprint can be ordered from Scientific American Offprints, W.H. Freeman & Company, 660 Market Street, San Francisco, California. 94104. The price is 20¢ per copy.

This student activity involves measuring the effect of the impact of water droplets on the soil. In order to encourage the students to create their own experiments to investigate rainsplash effects here are some questions which you can use to

stimulate investigations.

What could you use to measure the effects of falling water droplets on the ground? Where should the measuring devices or instruments be placed? How long should you let the water fall on the site?

Stakes can be used to provide the visual evidence of rain splash effects. If a top from a tin can is used to act as an umbrella it will prevent the mud splatters from being washed off. Stakes 45 cm. long and driven 10 - 15 cm. into the soil are suitable. Twenty minutes of sprinkling by a hose should be adequate to create a significant accumulation of mud splatters.

Questions you might ask your students to stimulate observations:

1. What is the purpose of the umbrella on the stake?
2. What are the effects of falling water on packed soil compared with loose soil?
3. What are the effects of falling water on soil on a slope compared with soil on a level surface?
4. What are the effects of falling water on soil with vegetative cover compared with soil with no cover?

When they have chosen the factors which they wish to investigate, they can select an area for the experiment. Have the students consider (1) the number of stakes needed to achieve adequate results, (2) the placement of the stakes, and (3) the amount of sprinkling time needed.

After the students have devised and carried out their experiment, encourage the students to:

1. Explain how the mud got on the measuring devices.

2. Tell where most of the mud was concentrated on the instruments. Account for what was observed. How high up does it reach?
3. Determine on which side of the measuring devices most of the mud or spots were concentrated. How would you explain this?
4. Predict what happens to the water after it falls.

How Do Raindrops Move the Soil?

What happens to the soil when raindrops hit the ground? Encourage the students to take a series of photographs (i.e. stopped action shots) of a drop about to hit the ground until after it has splattered and disappeared into the soil.

Students will require a camera with shutter speeds of 1/500 of a second or faster. Usually this means that they will have to bring a camera from home. Black and white film is satisfactory. There is a danger that they will get mud or water on the lense or in the camera. Perhaps you could make them aware of the hazards.

Students will waste film if they attempt to photograph drops falling randomly. Encourage them to begin by having drops fall in a pattern. This makes it easier to anticipate the impact of the water droplet. Water droplets are transparent, making them difficult to see when photographed. To make the droplets more distinguishable try using a coloured liquid such as ink.

Another Experiment

Pack some soil very tightly to fill a large diameter can (e.g. one pound coffee tin). The soil should be packed very hard. It is also necessary to have drainage holes in the bottom of the container so that water won't accumulate. If

this happens, the power of the falling water droplet is dissipated by the water in the soil. Place a few coins, bottle caps or stones on the soil. Under the right conditions miniature mesas and buttes resembling scenery of parts of B.C. and the United States are formed. The objects placed on the top of the soil can be compared with the resistant layers of rock found at the top of these buttes and mesas. (It is not absolutely necessary to put soil in a tin for this activity. It just makes it easier to make your observations if you can pick up the tin and observe it without lying on the muddy ground to see the buttes.)

Sprinkle for 15-20 minutes. Draw or photograph the can to get "before" and "after" pictures.

The Big Questions:

How do raindrops cause the soil to move?

What size of drops (large or small) make the big test changes?

Interest Arouser
A method by which you can get visual evidence of the variation in size of raindrops is to put flour in a box and sprinkle it for a few seconds. Allow the box to sit until the water droplets have evaporated. Granules will form which are about the size of the water droplets. The flour can then be put through a sifter and the various sizes of particles which remain can be observed and measured.

Try to get your students to develop another method by which you can measure the size of raindrops.

Where were the most dramatic splash effects seen - on bare soil, sand or sod?

Water on the Ground

The next section deals with the characteristics of flowing water, absorption of water, and variables affecting these characteristics.

The students should try to design their own experiments. They should be encouraged to control some variables and to record their observations in the form of quantitative data.

Which is More Absorbent?

Let's investigate the rate at which water sinks into different types of soil.

Try to find soils which have different characteristics such as plant cover, loose soil or packed soil. How else might they differ? When you choose the sites for your experiment, how can you be sure that the same amount of water is poured on equal areas. For example, suppose one person slowly pours a cup of water over an area one foot square, while another dumps a gallon of water over a spot of ground five inches square! Can you say that the soil at one site absorbs water more quickly than the other? How can you overcome this difficulty? How can you measure the rate at which water is absorbed into the soil?

Here is one way to do it:

Select two areas which have different soil conditions. Use two 48 oz. juice cans with the ends removed. Place marks 1 cm. apart on the inside of each can. Place a board across the top of each can and drive it 6-8 centimeters into the soil, by hitting the board with a hammer. Dump a litre of water into the cans.

Take your readings every 30 seconds for 10 minutes or until the water disappears. Make a chart showing how fast water disappears.

$$\text{Percentage of water absorbed} = \frac{\text{Height of water at last reading - present level}}{\text{Height at beginning of experiment}} \times 100$$

Some sample observations:

Readings	Time	Height of Water	Diff. between last reading	% of change	Total % absorbed since beginning
1	0	9.5 cm.	--	--	--
2	30 sec.	7.5 cm.	2 cm.	21%	21%
3	60 sec.	6.0 cm.	1.5 cm.	12%	33%

Here are some questions the students might be able to answer:

1. When did most of the water disappear - at the beginning, in the middle, or near the end of the experiment?
2. Which soil absorbed the water fastest?
3. What factors control the rate at which water sinks into the soil?
4. Where does the water go?
5. If you used a can only one-half as tall, what results might you get? How can you find out?
6. What would happen if the ground were frozen?

7. Speculate on what happens to water which remains beneath the surface of the ground. What happens to the water after it falls on the ground?

One Step Further

The previous experiment investigated the infiltration rates of water into different soil types. By having different groups carry out this experiment comparisons of results can be made. For example, they can determine whether it takes more time for the same amount of water to sink into clayey soil than sandy soil.

The following experiment concerns itself with the amount of water required to fill the spaces between the soil grains and what happens to the water if these spaces become filled.

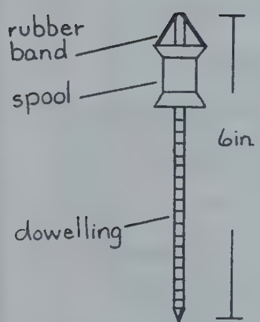
A method to accomplish this is to take either two 48 oz. or two 28 oz. tins, with only the tops removed, (make holes the exact size of the cans in areas of different soil characteristics). Fill the cans with the soil that was removed from the ground. The soil should be put into the cans so that it matches the surrounding soil of the test area in its profile and compactness.

When the cans are filled with soil, weigh them. Put them into the ground so that they are flush with the surrounding surface. Pour water at a moderate rate over each can until the soil can absorb no more. Pour off the excess surface water and weigh the cans again. This will give an indication of how much water the soil will hold, e.g. suppose the can full of soil weighed 2.1 kgs. before the water was poured. If you poured 1 litre (which is equivalent to 1 kg.) of water onto the can and weighed it afterwards, you would get an indication of how much

water was absorbed, e.g.:

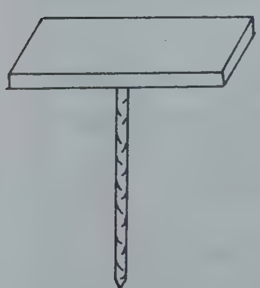
Reading afterward	2.7 kg.	This means that 0.6 kg. of water was absorbed while 0.4 kg. must have run off since you originally started with 1 kg. (1 litre) of water.
Reading before	2.1 kg.	
Difference in weight	.6 kg.	

SOIL COMPACTNESS



Idea I To determine the compactness of the soil you are testing.

Use a spool, a heavy rubber band, and a piece of dowelling slightly smaller than the hole in the spool. Put the rubber band over the top of the dowelling and attach to the spcol. Equidistant marks on the dowelling serve as indicators of soil compaction. To operate, push down on the spool with just enough force to have the dowelling enter the soil at a steady rate. The lowest point which the spool reaches when the dowelling enters the ground is dependent upon the soil compactness.



Idea II (for those who like to sit around)

Create a stool using a board for the seat approximately 3 inches wide X 12 inches long X 1 inch thick. Securely attach a piece of 1 inch X 12 inch dowelling to the seat. At different sites students can record how far the dowelling sinks into the ground under the weight of the person sitting on it. This also will provide an indication of soil compactness.

More on Soil Characteristics

The next lab may make those fragile students who abhor wet, cold or windy conditions feel more comfortable since it can be done inside.

Have the students select their samples from the same areas as where the previous investigation was done.

For Those Who Do Not Want To Get Their Feet Wet!

Let's dig deeper into the properties of soil affecting the flow of water through it.*

Take a distinct earth material, e.g. fine sand or medium sized gravel, etc. Dry the sample completely and if it is stuck in clumps, break it apart.

1. Put 100 ml. of each sample in the bottom of a plastic cylinder or column or other container which can easily be drained leaving the material behind.
2. Pack the soil in as tightly as possible.
3. To each sample, add enough water so that you have 500 ml. of water in each tube. Open up the bottom of the tubes to allow the water to drain. Measure the time for the water to run through each sample, and record. Collect the water which runs through.
4. Measure the amount of water which you collected. Compare the amount that you retrieved to the amount with which you started. Is there a difference? How can you account for this?

After doing the investigation, the students might try answering the following questions:

1. What type of soil absorbs the most water? The least water?

* Adapted from Earth Science Curriculum Project.

2. Which material appears to have the greatest amount of space between soil particles?
3. Which material allows water to pass through it most quickly? The slowest?
4. If more water was falling than could pass through the soil, what would happen to it?
5. What type of soil would be least affected by drought conditions?

Flowing Water

Some scientists are interested in the effects of water flowing in thin sheets over the ground. To measure the effects, long spikes with washers at the top, are pushed into the ground flush with the surface. After a rain, they examine them to see whether any soil has eroded from beneath the washers.

A Student suggested Experiment

A student suggested putting stakes (or popsicle sticks) at the top of the slope flush with the surface of the ground. At the bottom of the slope, the stakes would be protruding. This has the advantage of measuring not only erosion but also deposition. They can also get a comparison of the two aspects of sheet wash (i.e. erosion and deposition).

Does Water Flowing Across the Ground do Anything to the Soil?

Is the surface of the ground affected by running water?

Select an area which is fairly smooth but not necessarily level. Encourage the students to study the flow of water over the ground to see if its form or

pattern of flow changes and describe the changes observed.

The students should try to devise a method to measure whether soil is picked up by the water flowing over it. Two methods have been described above but there are many others which could be used.

Is there anything different about water flowing across the surface of the ground compared to water flowing in a stream or river?

After carrying out their experiment have the students explain how erosion can occur on slopes where apparently there are no streams to erode exposed ground. How can this type of erosion be prevented?

What Form Does Water Take as it Begins to Flow Across the Ground?

In this activity, we are interested in describing how water appears when it begins to flow across the surface of the ground.

Select different sites so that observations for several areas can be compared. Have the students pour water on the soil at a rate faster than the the soil can absorb it.

Here are some questions:

1. How does the flow of water compare between the sites? Compare the characteristics seen here with the flow of water in a stream or river.

2. When does it begin to flow (e.g. immediately after sprinkling, or ???)? Can you account for what you saw?
3. What does the flow look like? How does its form change if you follow it for some distance?

What's Wearing Away?

How can the soil be prevented from washing away along the slopes of your miniature stream?

Encourage the students to try various methods which prevent soil erosion.

1. Which methods were more successful? Least successful?
2. How might the information be used?
3. Where has soil erosion been a serious problem in the community?

Erosion by Running Water

The last section dealt mainly with rainsplash, infiltration of water into the soil and sheet wash. Sheet wash should be followed until it becomes channelled flow. The next section deals with the erosive work of water in streams and characteristics resultant from the erosion process.

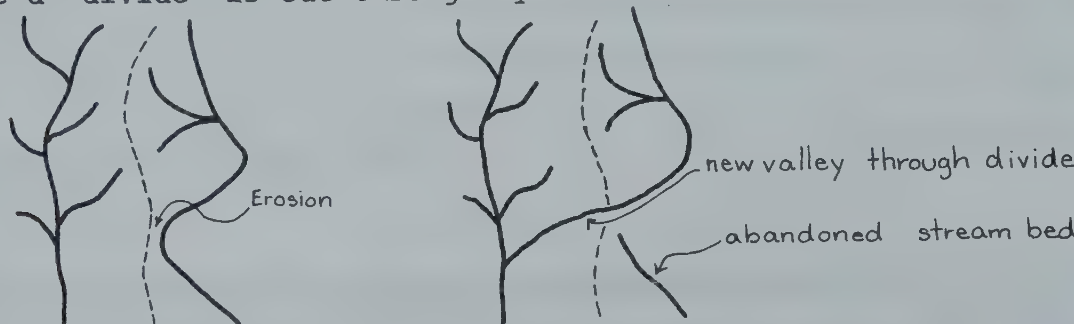
Headward Erosion

> Popsicle sticks can be used to mark out the dimensions of the upper part of miniature streams. Changes in valley dimensions caused by downcutting, channel widening and headward erosion can be observed and recorded if you have access to a Polaroid camera. Encourage your students to take before and after photographs.

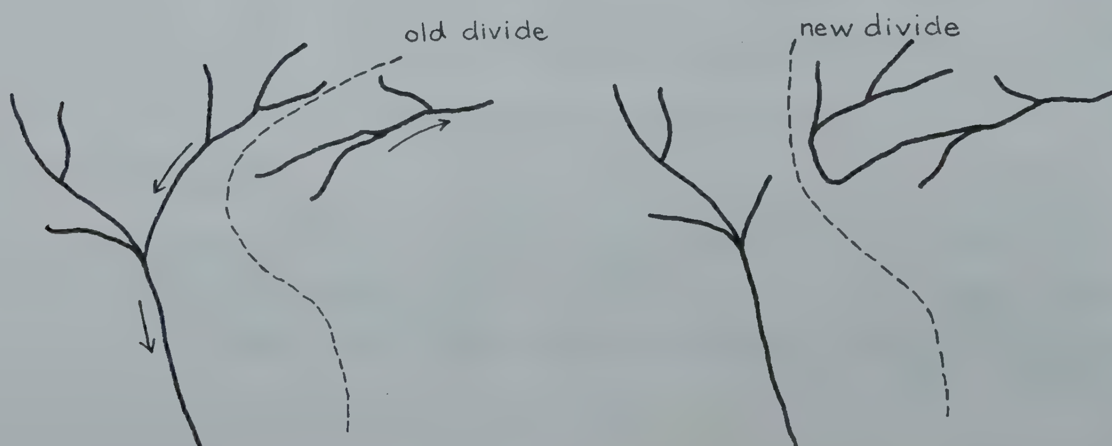
Stream Piracy

There are two ways in which one stream can capture another. In one case a barrier or "divide" is eroded away, in the second, a new barrier or "divide" arises causing a part of the stream to form a new channel and often connecting to another stream.

(1) Where a "divide" is cut through by erosion:



(2) Where a new "divide" is formed cutting off a segment of a stream:



Encourage the students to cause one stream to divert the flow of another stream. Can they make the streams flow in reverse direction? What determines the changes in direction of flow of the streams?

Suppose a tributary of a river in the United States cut into the path of a major river in Canada. Have the students consider the implications of this and what the possible results would be in terms of water flow.

What would result if the Fraser River was diverted at Hope so that it joined the Columbia River? Why would it be important to get it back into its own bed? How would it be done?

Encourage the students to find examples of actual diversions of rivers.

Stream Load

In this section we are interested in the load carried by a stream. There are three ways in which materials are carried. One consists of solid materials being bounced and rolled along the stream bottom. The second consists of materials suspended in the water; the third, of materials actually dissolved in the water.

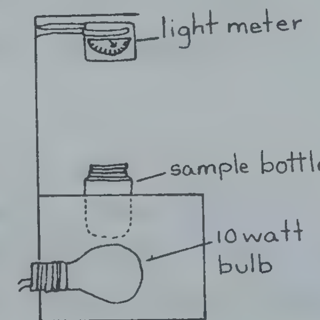
Besides investigating how materials are carried, encourage students to find which materials the streams can carry more easily, e.g. clay, sand, gravel, pebbles or dissolved solids.

Here are some questions the students may be able to answer:

1. What size of particles can a stream carry and how is this material transported? Examination of materials under the microscope will help to answer this question.

2. Which soil materials would be dropped first by a river and which would be carried farthest? What stream factors affect its ability to carry material? What soil particle factors affect its ability to be carried by flowing water?
3. By what different methods were the materials carried?
4. If someone threw salt in the water, would it be rolled along the bottom, carried in suspension, or dissolved?
5. Would erosion be possible if streams could not carry materials? Explain.

Materials in Suspension: (see diagram)



A simple apparatus can be constructed so that students can determine the relative amounts of materials which are suspended in water from different sources.

The students should be encouraged to collect samples from various locations such as a bog, stream, tap, lake, ocean, salt pond, ditch, aquarium, etc. By using the apparatus illustrated at the right or other similar devices the students can determine the relative amounts of materials held in suspension. The materials can also be filtered out and the filter paper dried and placed over the light source. With this method, a stronger light source may be necessary if there is a large amount of material in suspension.

Materials in Solution:

The filtered out samples from the previous experiment can be allowed to

evaporate to determine the amount of dissolved material. Be sure to include samples of sea water or salt pond water.

Some questions to ask:

Where does the material in suspension or solution come from?

Where does the material end up?

Why is the sea salty?

What kinds of material in solution or suspension are called "pollution"?

Do Streams Have Different Shapes in Different Places?

Is there a relationship between different cross-sectional shapes of a channel and the processes occurring there?

Encourage the students to select various parts of the miniature stream and determine the cross-section of it in various places and draw to scale the shape of what they see.

Get them to study other miniature streams to see what is occurring there. What is the relationship between the cross-sectional shape and processes observed?

Try to acquire data for a river near you. (The Inland Waters Branch of Environment Canada, or either the Geology Department, or Engineering Hydrology Department of the University of B.C. can provide you with some data.).

Below is a chart of hypothetical depth readings taken for the cross-section of a stream. Students might try plotting this data prior to taking readings outside.

Data Table	Length	Distance from Headwater	Diagram	Width	Depth Readings
1. Mythical River	240 mi.	12 mi.		37 ft.	- taken every 3 ft.: 2 1/2, 8, [illegible] 25, 22, 17, 10, 7, 4, 3, 1.
		118 mi.		250 ft.	- taken every 10 ft.: 3, 10, [illegible] 15, 16, 17, 17, 18, 16, 16, [illegible] 17, 19, 20, 21, 19, 16, 13, [illegible] 7, 4, 2, 1, 1 1/2.
		235 mi.		440 ft.	- taken every 20 ft.: 1, 2, [illegible] 4, 2, 6, 9, 12, 13, 14, 17, [illegible] 18, 25, 22, 16, 14, 12, 11, [illegible] 16, 12, 10, 10, 10, 6.

Slopes

Is there a relationship between the slope of a stream and the processes occurring there? Begin by working out a method to measure the angle of the slope of something, e.g. the slope of the roof of a house. Then encourage the students to find the slope of the channel at different locations of their miniature stream.

1. What kind of slope would you find where sandbars and deltas are found?
2. How would it compare with what you found near the headwaters?

What is it Like for a Real River?

Students can use topographic maps to determine the length of a river. If they use thread to follow the course of it, they can compare the changes in altitude at regular intervals along its course. When they have finished, they should be able to produce a chart similar to the one below. The data for this chart was partly secured this way.

River	Total Length	Distance from Headwaters	Ht. Above Sea Level	Slope
Resarf River	850 miles	0	3721	
		40	2800	
		83	2311	
		132	2100	
		160	1725	
		214	1350	
		250	1194	
		289	950	
		316	867	
		350	808	
		395	675	
		425	597	
		470	450	
		505	389	
		547	332	
		600	293	
		647	275	
		691	216	
		733	198	
		764	100	
		794	57	
		820	33	
		840	13	
		850	0	

A Real Challenge

Have the students speculate on the cause of the irregular profile of the river. See if they can determine where waterfalls and rapids might be found. Have them explain what is occurring just above, at, and below the irregularities.

Finding Its Own Course

If you make a channel straight, will it stay that way?

Encourage the students to straighten a portion of their channel by any means they wish other than having it run through a pipe, etc.

Have the students observe and record changes that occur and explain them.

The American Corp of Army Engineers have done precise experiments based on the above activity. After a number of hours, the channel always begins to meander.

Where is the Current Fastest?

Have the students observe the flow of water in their miniature river system. Encourage them to determine the portions of the river where the current is fastest and/or slowest.

Now you see it, Now you don't!

Many rivers have sandbars in them. Sometimes sandbars are used as parks or campsites. Sandbars in the Fraser were sources for gold. Gold still can be found there.

Encourage the students to investigate the following questions:

1. What conditions lead to the development of sandbars?
2. Where would you expect to find them?
3. Discuss whether the sandbars are permanent or temporary features.
4. What is the relationship between a sand bar and a sand dune?

If you have a movie camera

Study various miniature streams to see if there appear to be common features. After studying your river systems and identifying common features, shoot a film of those aspects which you think are important. Using a film splicer and reference books, make a film which you think shows the major features. If you wish, a soundtrack for your movie can be made using a tape recorder.

What are Lakes?

Students can easily form a lake in their river system. Here are some questions which they can investigate:

1. What causes lakes to form?
2. How does a lake differ from a river?
3. How does a lake differ from a reservoir behind a dam? In which ways are lakes and reservoirs similar?

Encourage the students to compare the way in which they formed their own lake with the ways in which natural lakes are formed.

Are Dams Permanent?

Using soil and other materials encourage the students to make a dam. Here are some questions the students can investigate:

1. What happens in the reservoir which forms behind it?
2. What natural structure is a dam similar to?
3. What happens just below the dam? Is anything happening to the dam itself?
4. Do dams have a lifespan? Explain.
5. Why are dams often a source of controversy? Can you predict which arguments you think will eventually win out?

Are Waterfalls Permanent?

Encourage the students to make a waterfall using earth materials such as mud, stones or sticks, etc. (You may wish to encourage the use of only one type of material and compare dams made from various types of material.)

Encourage the students to:

1. Observe what happens to it over a period of time. (Try using a camera). Account for what you saw.
2. Do some research on Niagra Falls and report on it, past and future.
3. What practical uses do waterfalls have?

I Think Your Mouth Gets Bigger Every Day!

You can suggest that students devise a method by which they can find the dimensions of the mouth of a stream

at the beginning of the experiment, and measure the changes that occurred over intervals of time.

Have them describe the changes at the mouth of a miniature stream. How do they compare with what might be found at the mouth of the Fraser. For example, what caused the changes that were observed?

Have the students investigate the development of deltas. How are deltas and sand bars similar? How are they different?

For a Job Well Done

The students now have completed the activities. You have probably heard nearly all the reports and hopefully will see an excellent student made film. All of these things relate to small-scale duplications of features found in the water erosion cycle.

Why not take a field trip or bus tour to see those larger scale features. It sounds useful, doesn't it?